

TRAUMA TO THE ABDOMEN: II. MANAGEMENT*

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THE increased incidence of accidental trauma combined with more rapid transportation of patients and improved resuscitation methods has increased the number of severe and complex abdominal injuries that confront the surgeon. We shall attempt to review briefly the current surgical management of some of the more common abdominal injuries. The diagnosis of abdominal trauma and the management of abdominal vascular injuries are discussed elsewhere in this symposium.

OPERATIVE APPROACH

Once a diagnosis of intra-abdominal injury is established and resuscitation instituted, the abdomen is explored. A long midline incision is preferred because it is made more rapidly than other incisions, it gives wide access to all parts of the abdomen and may be extended proximally as a sternal-splitting incision for control of the vena cava or for the treatment of cardiac wounds, and it can be closed rapidly.

For a patient who arrives "in extremis" with massive intra-abdominal blood loss, left thoracotomy, and occlusion of the thoracic aorta as a preliminary to exploratory laparotomy is worth consideration. This approach was suggested by Ledgerwood et al. after their experience with 11 patients who first had laparotomy and suffered immediate cardiovascular collapse when the tense hemoperitoneum was released.¹ Following rapid control of the thoracic aorta through a left thoracotomy, six of the 11 patients were resuscitated and had subsequent repair of their injuries. On the basis of this experience, Ledgerwood et al. recommend left thoracotomy and thoracic aortic occlusion before laparotomy in patients who arrive with a tense, blood-filled abdomen and refractory hypotension from massive intra-

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abdominal bleeding. With control of the hemorrhage, resuscitation can be completed while maintaining cardiac and central nervous system perfusion and minimizing the possibility of cardiac arrest. Following laparotomy, the abdominal aorta is occluded at the lowest possible site, and the clamp on the thoracic aorta is released to allow perfusion of much of the abdominal viscera. Using this approach in 29 patients, the same authors were able to resuscitate 22 of these patients, and half ultimately survived.

The Ledgerwood approach has merit in selected patients but can result in needless thoracotomy if used indiscriminately. In most instances the abdominal aorta can be controlled rapidly following laparotomy alone, using the aortic occlusion clamp described by Ledgerwood et al. or the flat blade of a Richardson retractor wrapped with a laparotomy pad, as suggested by McClelland.² It should be noted that in the Ledgerwood series the survival rate was 36% in the 11 patients treated initially by laparotomy and 38% in the group that had a preliminary thoracotomy.

STOMACH

Wounds of the anterior surface of the stomach are readily apparent at operation, but posterior perforations are easily missed unless that portion of the stomach is examined by opening the lesser sac. Gastric wounds are repaired by using a two-layer technique: a continuous, locking 2-0 chromic catgut suture through all layers of the gastric wall for hemostasis and a second layer of interrupted nonabsorbable sutures. Drains are not indicated, but it is important to suction the peritoneal cavity to remove any spilled food particles or gastric juice. Rarely, extensive injuries of the stomach may require resection.

DUODENUM AND SMALL INTESTINE

The small intestine is injured most frequently by penetrating wounds of the abdomen. Small perforations or lacerations are closed with a single layer of interrupted nonabsorbable suture after individual bleeding points are ligated. With missile injuries it is important to search for an even number of perforations unless a tangential wound can be proved. With multiple perforations, small wounds along the mesenteric border are easily overlooked. Larger wounds or multiple perforations in a short segment of bowel often necessitate segmental small bowel resection. Similarly, contusions of the small intestine caused by blunt trauma should be resected if any doubt exists about the viability of the bowel wall.

The type of repair used for closure of a duodenal injury depends largely on the size of the defect. Most duodenal injuries can be managed by debridement of the wound edges, two-layered closure, drainage, and some form of duodenal decompression. Repair of larger defects may be possible without compromising the lumen by wide mobilization of the duodenum and closure without tension in a transverse manner. For the 20% to 25% of injuries that are too large for primary closure, a variety of repairs may be considered, including complete division of the duodenum and end-to-end anastomosis, the jejunal patch technique, use of a Roux-en-Y loop of jejunum sutured around the defect, duodenal diverticulization, or, when associated with severe injuries of the head of the pancreas, a pancreaticoduodenectomy.

Lacerations of the distal stomach that extend into the duodenum can often be closed primarily as a pyloroplasty. For more extensive wounds involving the first portion of the duodenum, a Billroth II gastrectomy may be the best alternative.

Large lacerations in the second and third portions of the duodenum can be repaired by the jejunal-patching technique recommended by Thal.³ The technique uses a retrocolic loop of proximal jejunum sutured over the wound in the duodenum. An inner row of catgut sutures is placed between the torn edges of the duodenal defect and the seromuscular layer of the jejunum, and an outer layer of nonabsorbable sutures is used to approximate the seromuscular coats. The procedure has also been advocated to buttress a tenuous primary closure. Although of occasional value, use of either a jejunal or an omental patch to reinforce an otherwise unsatisfactory closure is discouraged.

When there is sufficient loss of duodenal tissue to exclude suture closure, the most useful technique for repair in the absence of severe pancreatic injury is a duodenojejunostomy. This is accomplished by constructing a defunctionalized Roux-en-Y jejunal limb brought up in a retrocolic position and sutured to the duodenal defect in an end-to-side manner. For larger defects, the end of the jejunum may be closed, and a side-to-side jejunoduodenostomy performed. The technique is also useful for the repair of a duodenal fistula that develops after primary closure.

The Berne duodenal diverticulization procedure should be considered in more extensive duodenal injuries and in selected cases of combined pancreatic and duodenal injuries.⁴ As illustrated in Figure 1, the procedure consists of antrectomy, gastroenterostomy, duodenal decompression by

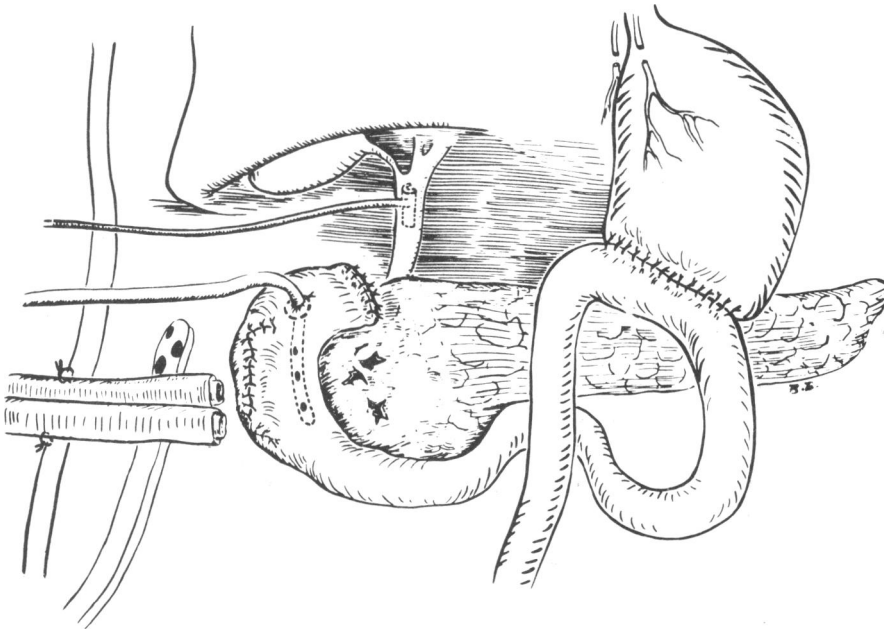


Fig. 1. Duodenal diverticulization. Reproduced with permission from Dun-Donnelley Publishing Corp. and Berne, C. J., Donovan, A. J., White, E. J., and Yellin, A. E.: Duodenal "diverticulization" for duodenal and pancreatic injury. *Am. J. Surg.* 127:503, 1974.

end or side duodenostomy, and insertion of a T-tube into the common bile duct. These maneuvers divert or reduce the flow of bile and pancreatic and small bowel secretions from the injured area. If the wound is massive and associated with severe pancreatic and biliary tract injury, a pancreaticoduodenectomy may be the only alternative.

All duodenal injuries, regardless of size, should be drained externally, using Penrose drains (sump drains are used for more extensive injuries) because anastomotic leaks and fistula formation occur in approximately 5% to 10% of cases. Drains are left in place for a minimum of six to seven days, and nasogastric suction maintained for a similar period of time. Before removal of the nasogastric tube, gastrografin is injected through it to check the integrity of the repair. Some form of duodenal decompression is also to be considered after the repair of most wounds of the duodenum. This may be accomplished by inserting a nasogastric tube into the duodenum through the nasopharynx or by a gastrotomy. Additional holes are made in the tube to decompress simultaneously both the stomach and the duodenum. Alternately, a jejunostomy tube can be threaded retrograde into

the duodenum. Another useful technique, originally described for duodenal decompression after a difficult duodenal stump closure, involves insertion of a #10 Foley catheter through a small stab wound in the lateral or anterior wall of the duodenum near the injury.⁵ The tube serves as an effective duodenal vent, and fistula formation from the tube site following removal is extremely rare.

Operative treatment of a duodenal hematoma caused by blunt abdominal injury evacuates the hematoma and closes the defect in the seromuscular coat after control of any bleeding points. If it is an isolated lesion without evidence of perforation by hypaque and then by barium upper gastrointestinal series, the lesion may be treated conservatively as recommended by Fullen and associates.⁶ The 11 patients treated by restriction of oral intake, nasogastric suction, and intravenous maintenance fluids all survived without complications. If duodenal obstruction persists despite conservative management, celiotomy, which has quite a low mortality rate, is indicated.

PANCREAS

Isolated pancreatic injuries are rare; they occur in less than 10% of all patients with pancreatic trauma. Profuse hemorrhage from such wounds is most often caused by an associated major vascular injury. Damage to the pancreas is always suspected in the presence of hematomas in the upper retroperitoneum or peripancreatic area. The body of the pancreas is visualized by dividing the gastrocolic omentum, and the head of the pancreas is explored by performing a Kocher maneuver. If necessary, the spleen can be mobilized and retracted medially to uncover the posterior aspect of the body and tail of the pancreas. The general principles of management of pancreatic injury include control of hemorrhage, debridement (by resection if necessary), and wide drainage of the injured area, using both Penrose and sump drains.

Simple pancreatic contusions not associated with continued bleeding or with disruption of the pancreatic duct or capsule are treated by drainage alone, and the drains are brought out by the shortest and most direct route. Lacerations not associated with loss of tissue or duct injury are best treated by closing the defect with nonabsorbable suture. Sutures made of synthetic materials, such as nylon or polypropylene, are preferred because absorbable sutures disintegrate rapidly when exposed to pancreatic secretions. If tissue loss precludes closure of the defect, hemostasis and thorough drainage of the wound will suffice.

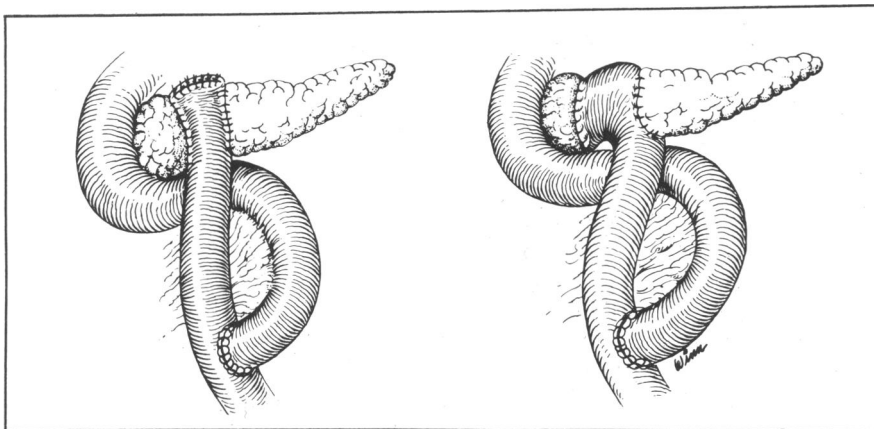


Fig. 2. Technique of Roux-en-Y anastomosis of both ends of transected pancreas. Reproduced with permission from Jones, R. C. and Shires, G. T.: Pancreatic trauma. *Arch. Surg.* 102:424-30, 1971. Copyright 1971, American Medical Association.

A missed injury of the main pancreatic duct will usually cause formation of a pseudocyst or abscess, and if the duct injury is treated by drainage alone, a persistent pancreatic fistula is inevitable. Such injuries require either resection or implantation of the duct into the gastrointestinal tract or a combination of the two techniques. Distal pancreatectomy is a safe and effective method to treat a wound of the body or tail of the pancreas involving the major pancreatic duct. All pancreatic tissue distal to the duct injury is removed, the duct is ligated (if it can be found), and the proximal cut edge of the pancreas is beveled in a fish-mouth fashion. The cut surface is then closed with interlocking mattress sutures to obtain hemostasis, and the area is drained with both sump and Penrose drains. If there is significant contusion of the remaining pancreatic tissue and the possibility of more proximal duct obstruction, the end of the pancreas can be implanted into a defunctionalized Roux-en-Y jejunal limb. Up to 75% of the gland can be removed without causing pancreatic insufficiency or diabetes. Only one patient developed diabetes in a series of 60 distal pancreatic resections for pancreatic injury reported by Yellin et al.; eight of the injuries were to the right of the superior mesenteric vessels.⁷

Major injuries with duct disruption that would require resection of more than 75% of the pancreas are best treated by implanting both the proximal and the distal segments of the pancreas into a defunctionalized Roux-en-Y jejunal limb. The limb should be at least 30 cm. long and placed in a

retrocolic position. Following thorough debridement, the divided ends of the pancreas may both be sutured in an end-to-side manner to the jejunum after closure of the distal end of the jejunal limb. However, it is preferable to perform an end-to-end anastomosis to the proximal pancreatic segment and reimplant the distal segment in an end-to-side fashion, as illustrated in Figure 2. Both methods eliminate the need to find the severed ends of the duct and preserve all functioning pancreatic tissue.

Rarely, an injury may leave little proximal pancreatic tissue intact without devascularizing the duodenum. The remaining proximal pancreatic tissue can be oversewn (as in a Child's 95% pancreatectomy), and any uninjured distal pancreatic tissue can be implanted into a jejunal limb. A T-tube cholangiogram is performed to assess the distal common duct. If injured, the duct is repaired primarily or reimplanted into the gastrointestinal tract.

Suturing a defunctionalized jejunal limb over a wound of the anterior surface of the pancreas has been advocated in selected cases. The procedure is rarely indicated because it requires the presence of an intact posterior pancreatic capsule. If the latter is disrupted, drainage of pancreatic secretions into the retroperitoneal space will invariably result in abscess, pseudocyst, or fistula formation.

Severe combined injuries of the duodenum and pancreas are treated by either a Berne duodenal diverticulization procedure, as described previously, or by pancreatoduodenectomy. The latter procedure is indicated only when the head of the pancreas and duodenum are irreparably damaged, precluding any lesser procedure. An average mortality rate of 35% has been reported following Whipple procedures for combined injuries, and mortality rates as high as 50% to 60% have been reported.⁸ While some of the mortality is due to associated injuries, there is little doubt that indiscriminate pancreatoduodenectomy has contributed to these high rates.

The overall mortality of isolated duodenal injuries or isolated pancreatic injuries is approximately 20%. With combined pancreatic and duodenal injuries, the mortality rate is more than doubled and in some reports exceeds 60%. Complications are frequent and include pancreatic and duodenal fistulas, pseudocyst formation, and hemorrhage from vascular necrosis. Early surgical intervention and an aggressive approach to pancreatic injuries (including resection when necessary), wide local drainage, and appropriate fluid and nutritional support during the postoperative period have helped to lower the mortality rate. Jones and Shires reported a

decrease in mortality due to blunt pancreatic injuries from 37% in 1965 to 16% in 1970; the mortality for isolated pancreatic injuries was less than 5%.⁹

SPLenic INJURIES

Once the diagnosis of splenic injury has been made, regardless of the extent of that injury, immediate splenectomy is indicated. However, the advisability of splenectomy in children is controversial. Singer reported that the incidence of fatal sepsis in children after splenectomy is 58 times more than in the general population.¹⁰ Other studies leave little doubt that the susceptibility to sepsis is increased, although most studies included children who had splenectomies for hematologic disorders and, therefore, questionable immunocompetence.¹¹

Recent reports of successful repair of splenic injuries have appeared, and such therapy deserves consideration in the younger age groups.¹² However, most patients with splenic injuries are still treated by splenectomy regardless of age. Although it remains controversial and is not within official prescribing information, some medical authorities advise penicillin therapy similar to that employed in rheumatic fever prophylaxis in infants and young children. Because most of the infections are pneumococcal, the recently available pneumococcal vaccine may alter this thinking.

The technique of splenectomy is familiar enough to preclude additional comment, except that initial isolation of the splenic artery and vein above the superior border of the pancreas would appear to have little place during an emergency splenectomy. Whether the splenic bed should be drained after splenectomy is controversial. While drainage is not necessary after many elective splenectomies, there is little question that it should be employed in most instances after emergency splenectomy. Drainage is indicated because of possible damage to the tail of the pancreas, whether from the original injury or from an iatrogenic cause. Often, a large hematoma in the splenic mesentery will obscure the distal end of the pancreas, and injury secondary to clamp placement cannot be excluded. The high reported incidence of drain tract and subphrenic infections is related primarily to associated injuries. Naylor and Shires reported subphrenic abscess in only 3.4% of 408 patients undergoing splenectomy for trauma, a majority occurring in patients with associated bowel injuries.¹³ Among the 72 patients with isolated splenic injury, there were no sub-

phrenic abscesses, and the incidence of drain-tract infections was only 1.3%.

LIVER INJURIES

An increase in the number of severe liver injuries has been reported during the past decade. The liver is second to the spleen as the most commonly injured structure following blunt trauma, and second to the small bowel following penetrating trauma. The overall mortality rate from hepatic injury averages 15% (ranging from 1% for simple stab wounds without associated injury to 50% in patients who have multiple injuries or who require major hepatic resections).

Following operative exposure, temporary control of hemorrhage from liver wounds is obtained by direct, manual pressure over the bleeding sites or by compression of the hepatic artery and portal vein (Pringle maneuver). Interruption of hepatic blood flow is tolerated well by the normothermic liver for about 15 minutes, after which compression must be released to allow a few minutes of uninterrupted perfusion.

Treatment involves hemostasis, removal of devitalized tissue, liberal drainage, and routine use of antibiotics. In 50% to 70% of patients, bleeding from liver injuries will have stopped by the time the abdomen is opened or after brief manual compression. Suturing nonbleeding liver injuries is not necessary, as emphasized by reports from Shires et al. and Lucas and Ledgerwood; adequate drainage is all that is necessary.^{14,15} These authors reported no rebleeding among several hundred patients where bleeding had stopped spontaneously. Using large Penrose drains, drainage is established by the shortest and most direct route. For most lateral and posterior liver injuries, drains should exit posterolaterally at the tip of the 12th rib; with extensive injuries and following major resections, better drainage is obtained through the bed of the resected 12th rib.

If bleeding persists, direct suture ligation of vessels is preferred to minimize the amount of devascularized liver tissue. If this is not possible, simple interrupted sutures can be placed 2 cm. from the margin of the liver wound using zero chromic catgut suture swaged onto a large blunt-tipped liver needle. The sutures are placed on either side without approximating the wound, as illustrated in Figure 3. Attempts to close deep lacerations of the liver using large interlocking mattress sutures to obtain hemostasis are not indicated because large collections of bile and blood, with abscess formation deep in the substance of the liver or hemobilia, may result.

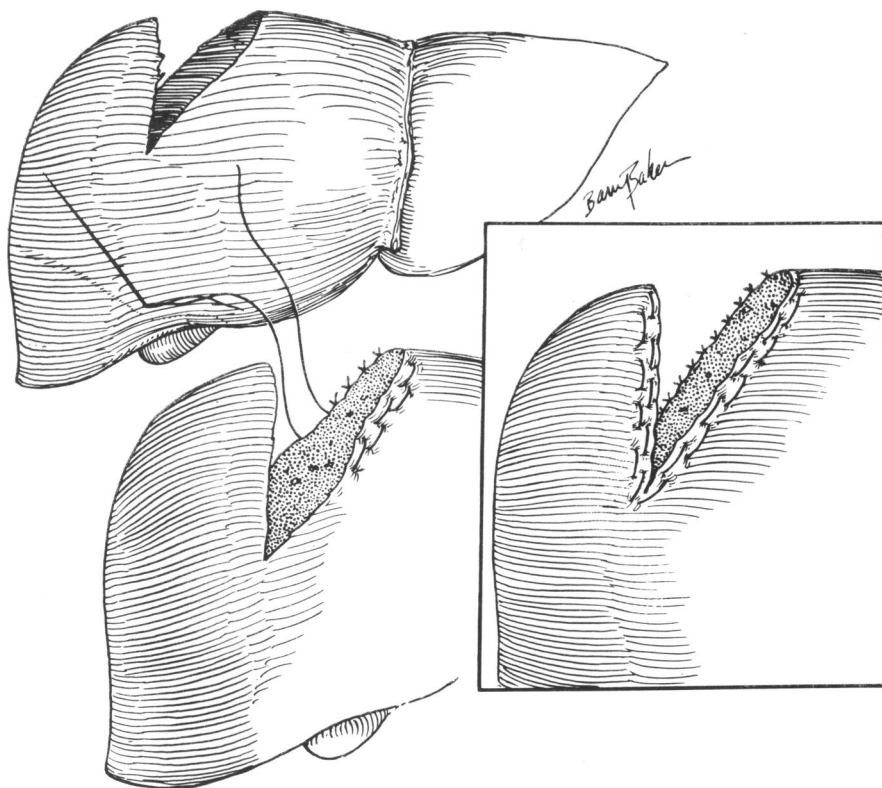


Fig. 3. Technique for placement of mattress sutures in a deep laceration of the liver if hemorrhage cannot be controlled by direct suture ligation of bleeding vessels. Reproduced with permission from De Bakey, M. E. and Jordan, G. L., Jr.: *Surgery of the Liver*. In: *Diseases of the Liver*, 3rd ed., Schiff, L., editor, Philadelphia, Lippincott, 1975, chap. 34, Figure 34-2, p. 1091.

Similarly, the use of hemostatic materials, such as Surgicel or Gelfoam, is discouraged because they predispose to abscess formation or rebleeding during the postoperative period. Microcrystalline collagen powder (Avitene) may occasionally help to control oozing from liver wounds and, unlike other materials, does not cause significant foreign-body reaction.

Bleeding from a relatively inaccessible site deep in the liver, as from a bilobar gunshot-wound tract, is a formidable challenge. If the source of bleeding is within a few centimeters of the liver capsule, simple sutures placed around the wound without closing the defect or limited resectional debridement may suffice. Continued bleeding may necessitate ligation of an appropriate branch of the hepatic artery or extensive opening of the tract

with ligation of bleeding points and resection when indicated. If successful, ligation of one of the main hepatic artery branches is preferred because it causes considerably less morbidity than resection.¹⁶ Ligation of the right or left hepatic artery has proved a safe and occasionally effective method to control arterial hemorrhage in deep or complex injuries of the liver. However, it must be used in a discriminate manner; test occlusion of the vessel, using a vascular clamp to determine whether hemorrhage can be controlled in this manner, should precede ligation. Continued bleeding after occlusion often indicates that the source of bleeding is venous in origin.

Resection for major hepatic injuries should be limited when possible to removal of damaged, devascularized liver, including a margin of healthy tissue. Anatomic hepatic lobectomy is rarely indicated and is performed only when limited wedge resection, sublobar resection, or tractotomy to control bleeding will not suffice. The 2% to 3% of patients who do require hepatic lobectomy usually have massive, shattering injuries of the liver or injuries of the retrohepatic vena cava or major hepatic veins. If the decision is made to perform such a resection, manual compression of bleeding sites and a Pringle maneuver are instituted, while the midline incision is extended to perform a median sternotomy. As noted by McClelland, median sternotomy is preferable to a right thoracoabdominal incision because it is made and closed more rapidly, causes considerably less diaphragmatic injury, provides better access to the vena cava and hepatic veins, permits easier insertion of a retrohepatic vena caval shunt if required, and causes less postoperative pain and fewer pulmonary complications.²

Successful management of injuries of the retrohepatic vena cava or of major hepatic veins often depends on rapid vascular isolation of the liver. This can be achieved by placing occlusive vascular clamps across the aorta just below the diaphragm, the porta hepatis, and the inferior vena cava above and below the liver, as described by Heaney et al.¹⁷ The technique is associated with a significant incidence of cardiac dysrhythmias and renal insufficiency, and it has been abandoned largely in favor of an intracaval shunt inserted through the right arterial appendage, as described by Shrock.¹⁸ Another useful technique involves insertion of a large Foley catheter directly into the exposed laceration. Following balloon inflation, traction on the catheter may control bleeding sufficiently to allow repair.

Unfortunately, use of the technique is limited to isolated injuries that can be exposed easily and rapidly.

Treatment of subcapsular or intrahepatic hematomas due to blunt trauma remains controversial. Lucas and Ledgerwood recommend that hematomas be incised and evacuated and bleeding points controlled by whatever technique is suitable.¹⁵ Treated nonoperatively, the hematomas may expand and rupture with delayed intraperitoneal bleeding, form an abscess, or decompress into the biliary tree and cause hemobilia. However, Richie and Fonkalsrud reported successful nonoperative management in a series of patients with hepatic hematomas.¹⁹ They perform an emergency liver scan on patients with probable blunt hepatic trauma who have no evidence of persistent hemorrhage or shock and have no other indications for immediate laparotomy. If the patient's condition is stable and subcapsular hematoma is seen on liver scan, the patient is kept in the hospital under close observation and followed by serial liver scans. Hepatic arteriography may be a more useful technique to delineate the size and location of the hematoma and the source and severity of any persistent bleeding. Another advantage of selective arteriography is that it may allow Gelfoam embolization of the bleeding vessel through the hepatic artery catheter.

The mortality for nonoperative treatment of traumatic hemobilia approaches 100%, and prompt surgical intervention is essential. Hepatic resection or hepatectomy and direct exposure and suture ligation of the bleeding site has been the standard approach. Recently, successful control of hemobilia has also been reported following ligation of the right or left hepatic artery.

BILIARY TRACT

Injuries of the gallbladder are most frequently seen after penetrating abdominal trauma. Such injuries are best managed by cholecystectomy. If cholecystectomy is deemed inadvisable because of the condition of the patient, the laceration may be repaired primarily and protected by a tube cholecystostomy and liberal drainage of the area.

Injuries of the extrahepatic bile ducts are rare, and diagnosis of isolated ductal injuries may be delayed for several days until the onset of bile peritonitis. At the time of operation, blood or bile in the subhepatic space suggests injury to the structures in the hepatoduodenal ligament and requires thorough exploration of the area. Bile staining without an obvious

source of injury requires an operative cholangiogram. Lacerations of the common or hepatic ducts are closed primarily with 4-0 or 5-0 polypropylene suture over one arm of a T-tube inserted into the common duct through an incision above or below the injury. Complete transection of the common bile duct may be repaired by end-to-end anastomosis over a T-tube with interrupted sutures. If this is not feasible, the distal end of the bile duct is suture-ligated and the proximal end is anastomosed to a defunctionalized Roux-en-Y jejunal limb. An alternate approach suggested by Longmire²⁰ for the repair of small, thin-walled bile ducts involves ligation of the severed ends and performance of a cholecystojejunostomy.

COLON INJURIES

A majority of colon injuries are secondary to penetrating trauma; the incidence of blunt trauma is no more than 3% to 4% in most series. In the military, most wounds are caused by high-velocity missiles, and exteriorization of the damaged colon or primary closure and proximal diverting colostomy is the safest course. For stab wounds and low-velocity missile wounds seen in civilian practice, treatment varies depending on the cause, location, and extent of damage, the amount of fecal contamination, and the presence of associated injuries.

Small, clean lacerations on the antimesenteric border seen early with minimal or no peritoneal soiling may be closed primarily with a two-layer suture technique. Primary repair is avoided in most injuries of the left colon and in many gunshot wounds unless the perforations are small with minimal tissue destruction. In the presence of shock, severe associated injuries, and gross contamination of the peritoneal cavity and when there is considerable delay between the injury and surgical treatment, primary repair is not advised. Most colon injuries are best treated by exteriorization of the wound as a loop colostomy or by repair of the wounds and construction of a proximal diverting colostomy. For extensive wounds where a segment of the colon has been destroyed or devascularized, the involved bowel is resected and the two ends exteriorized as a proximal colostomy and mucus fistula.

Small wounds of the right colon and cecum may be repaired primarily and protected by construction of either a cecostomy or an appendicostomy. More extensive injuries are best treated by right colon resection and ileotransverse colostomy. In an unstable patient with multiple injuries and

extensive contamination of the peritoneal cavity, a temporary ileostomy and mucus fistula following resection may be the safer alternative.

For all injuries of the rectum, complete diversion of the fecal stream is necessary, and this is accomplished by a proximal double-barreled colostomy. If accessible, the rectal injury is repaired, but extensive dissection to visualize and repair the injury may result in devascularization of that segment of rectum. Whether the wound can be repaired primarily or not, retrorectal or presacral drainage is mandatory. If the injury is extensive or secondary to a high-velocity missile wound, all fecal material should be removed from the distal rectum as recommended by Lavenson and Cohen.²¹ This is accomplished by irrigating the defunctionalized segment of colon with copious amounts of saline solution until the return is clear.

Discussion

QUESTION: Dr. Canizaro, would you use a prophylactic chest tube in a patient with combined lower chest and upper abdominal penetrating trauma and with a negative chest roentgenogram to prevent the development of a tension pneumothorax prior to surgery?

DR. CANIZARO: Not in a patient with a stab wound of the chest or a gunshot wound of the upper abdomen, where passage of the missile through the thorax was doubtful. I would alert the anesthesiologist about the possibility of pneumothorax developing during surgery and be prepared to insert a tube at that time. Where penetration of the pleural space by a gunshot wound is obvious, I would consider placing a chest tube preoperatively, even in the absence of a demonstrable pneumothorax. A trocar should not be used to insert the tube in this situation because of the distinct danger of injuring the noncollapsed lung.

REFERENCES

1. Ledgerwood, A. M., Kazmers, M., and Lucas, C. E.: The role of thoracic aortic occlusion for massive hemoperitoneum. *J. Trauma* 16:610-15, 1976.
2. McClelland, R. N.: Trauma. *Sel. Read. Gen. Surg.* 4:24, 1977.
3. McInnis, W. D., Aust, J. B., Druz, A. B., and Root, H. D.: Traumatic duodenal injuries of the duodenum: A comparison of 1° closure and the jejunal patch. *J. Trauma* 15:847-53, 1975.
4. Berne, C. J., Donovan, A. J., White, E. J., and Yellin, A. E.: Duodenal "diverticulization" for duodenal and pancreatic injury. *Am. J. Surg.* 127:503, 1974.
5. Jones, R. C., McClelland, R. N., Zedlitz, W. N., and Shires, G. T.: Difficult closures of the duodenal stump. *Arch. Surg.* 94:696, 1967.

6. Fullen, W. D., Selle, J. G., Whitely, D. H., et. al.: Intramural duodenal hematoma. *Ann. Surg.* 179:549-56, 1974.
7. Yellin, A. E., Vecchione, T. R., and Donovan, A. J.: Distal pancreatectomy for pancreatic trauma. *Am. J. Surg.* 124:135-42, 1972.
8. Yellin, A. E. and Rosoff, L.: Pancreatoduodenectomy for combined pancreatoduodenal injuries. *Arch. Surg.* 110:1177-83, 1975.
9. Jones, R. C. and Shires, G. T.: Pancreatic trauma. *Arch. Surg.* 102:424-30, 1971.
10. Singer, D. B.: Postsplenectomy Sepsis. In: *Perspectives in Pediatric Pathology*. Chicago, Year Book Med. Pub., 1973, vol. 1, p. 285.
11. Dickerman, J. D.: Bacterial infection and the asplenic host: A review. *J. Trauma* 16:662-68, 1976.
12. Burrington, J. D.: Surgical repair of a ruptured spleen in children: Report of eight cases. *Arch. Surg.* 112:417-19, 1977.
13. Naylor, R., Coln, D., and Shires, G. T.: Morbidity and mortality from injuries to the spleen. *J. Trauma* 14:773-78, 1974.
14. Trunkey, D. D., Shires, G. T., and McClelland, R. N.: Management of liver trauma in 811 consecutive patients. *Ann. Surg.* 179:722-28, 1974.
15. Lucas, C. E. and Ledgerwood, A. M.: Prospective evaluation of hemostatic techniques for liver injuries. *J. Trauma* 16:442-51, 1976.
16. Mays, E. T.: Lobar dearterialization for exsanguinating wounds of the liver. *J. Trauma* 12:397-407, 1972.
17. Heaney, J. P., Stanton, W. K., Halbert, D. S., et al.: An improved technique for vascular isolation of the liver: Experimental study and case reports. *Ann. Surg.* 163:237, 1966.
18. Yellin, A. E., Chaffee, C. B., and Donovan, A. J.: Vascular isolation in treatment of juxtahepatic venous injuries. *Arch. Surg.* 102:566-73, 1971.
19. Richie, J. P. and Fonkalsrud, E. W.: Subcapsular hematoma of the liver: Nonoperative management. *Arch. Surg.* 104:781-84, 1972.
20. Longmire, W. R., Jr.: Management of injury to the extrahepatic biliary tract. *J. A.M.A.* 195:623-25, 1966.
21. Lavenson, G. S., Jr. and Cohen, A.: Management of rectal injuries. *Am. J. Surg.* 122:226-30, 1971.